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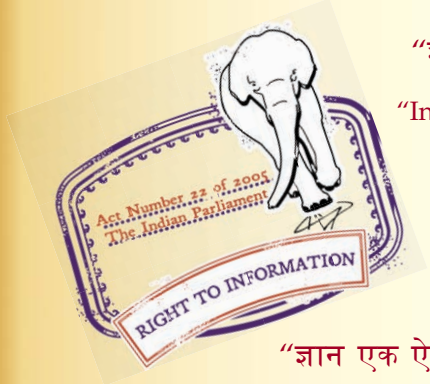
IS 6398 (1983): Code of practice for eddy current testing of ferrous seamless pipes and tubes [MTD 21: Non-Destructive Testing]



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"Knowledge is such a treasure which cannot be stolen"

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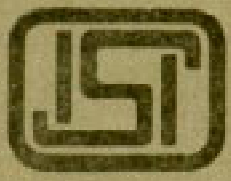
IS : 6398 - 1983
(Reaffirmed 2000)

Indian Standard

CODE OF PRACTICE FOR EDDY CURRENT TESTING OF SEAMLESS FERROUS PIPES AND TUBES

(First Revision)

UDC 669-462·3 : 620·179·1 : 621·3·014·4



INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

CODE OF PRACTICE FOR EDDY CURRENT TESTING OF SEAMLESS FERROUS PIPES AND TUBES

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR EDDY CURRENT TESTING OF SEAMLESS FERROUS PIPES AND TUBES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 25 August 1983, after the draft finalized by the Non-Destructive Testing Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1971. In this revision more details about testing procedures and reference standard has been incorporated. This standard is intended to be a guide for method of eddy current testing of seamless ferrous pipes and tubes. The recommendations given in this standard are based on accepted current practices.

0.3 This standard applies to the eddy current testing of ferrous pipes and tubes only. Eddy current testing of non-ferrous tubes will be covered in a separate standard.

0.4 In the preparation of this standard, assistance has been derived from the following publications:

BS 3889 : Part 2A - 1965 Methods for non-destructive testing of pipes and tubes : Eddy current testing of ferrous pipes and tubes. British Standards Institution, UK.

BS 3889 : Part 2B - 1966 Methods for non-destructive testing of pipes and tubes : Eddy current testing of non-ferrous tubes. British Standards Institution, UK.

ASTM E 309 - 1977 Recommended practice for eddy current testing of steel tubular products with magnetic saturation. American Society of Testing and Materials, USA.

1. SCOPE

1.1 This standard prescribes the methods of eddy current detection of defects in seamless pipes and tubular products of outer diameter from approximately 3·0 to 250·0 mm. This standard is applicable only to ferrous pipes of uniform cross section and composition.

2. PRINCIPLE OF TEST

2.1 The test is performed by passing the tube through or in the proximity of a coil(s) energized with alternating current at one or more frequencies. This alternating current induces eddy currents to flow in the tube as a result of electromagnetic induction. The test coil detects the resultant electromagnetic flux related to these currents. The presence of discontinuities in the tube shall cause change in flow of eddy currents. Where a discontinuity is present, the eddy current flow is impeded and changed in direction, causing significant changes in the associated electromagnetic field.

In the case of ferrous tubes the extent of change in electromagnetic field is also dependent upon the magnetic permeability of the material. The permeability variations inherent in ferrous tubes is often the cause of anamolous test results. The problem can be solved by the application of strong magnetic field in the region of the examining coil.

During the passage of the tube the changes in electromagnetic response caused by the presence of discontinuities in the tube are detected by the test coil which are amplified and modified in order to actuate an audio or visual indicating device (such as a cathode ray oscilloscope or a recorder), a mechanical marker or a combination of these.

3. TERMINOLOGY

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Test Coil Assembly — One or more coils supplied with alternating current and placed in proximity to, and, therefore, electromagnetically coupled to the material being tested. The test coil assembly induces eddy currents in the material being tested and responds to variations in these eddy currents caused by discontinuities in the material. The coil may be either a probe coil or an encircling coil of the absolute or differential type.

3.2 Depth of Penetration — For a given material and for given conditions of test coil assembly, frequency of alternating current supplied

to coil, etc, the magnetic field strength and consequently the intensity of induced eddy currents in the material decreases in value from the surface (close to the coil) towards the interior of the material. The depth at which the magnetic field strength or the intensity of induced eddy currents has decreased to $1/e$ (or 37 percent) of its surface value is called ' depth of penetration ' where e is the base of Neperian logarithm. Synonymous terms are ' standard depth of penetration ' and ' skin depth '.

3.3 Eddy Currents — Electrical currents caused to flow in a conductor by the time or space variation, or both, of an applied magnetic field.

3.4 Effective Depth of Penetration — Though theoretically the intensity of induced currents reduce to zero at infinite depth, for practical purposes considering the test system and detection capability, the induced eddy currents in the material do reach zero value at finite depth beyond which the test system does not ' see ' the material. This depth in the material at which the induced eddy current intensity practically reduces to zero is called ' effective depth of penetration '. In effect, the test system does not detect any defect situated beyond the effective depth of penetration in the material.

NOTE — The frequency of alternating current fed to the coil assembly shall be so chosen that wall thickness of the material is less than the effective depth of penetration and the condition stipulated in **5.4** is satisfied.

3.5 End Effect (or Edge Effect) — The effect of the magnetic field caused by the geometric boundaries of the test specimen that makes it impractical to apply electromagnetic test methods to the associated regions of the test specimen. A large indication generally develops which masks the indication of discontinuities in this region.

3.6 Filters — It is a network that transmits energy at frequencies within one or more frequency bands and attenuates energy at all other frequencies.

3.7 Magnetic Saturation (Applicable for Ferrous Pipes and Tubes Only) — A state wherein a magnetic material, as a result of the application of a strong magnetic field, exhibits a sufficiently small degree of its magnetic characteristics, such as permeability and hysteresis that the only properties subject to measurements or variations are its dimensions and electrical conductivity.

3.8 Permanent Magnet — A material of high magnetic retentivity that has been strongly magnetized.

3.9 Speed Effect — This is the phenomena in which a change in signal voltage is caused by the relative motion between the specimen and a test coil assembly.

4. EQUIPMENT

4.1 The main apparatus shall consist of a source of alternating current of a fixed or variable frequency applied to a test coil assembly, and an electronic detecting system to sense and indicate variations in the output of the coil assembly. The detecting system may include a phase selector and filter circuit. The frequency of the instrument shall be such that the effective depth of penetration is greater than the wall thickness of the tube under inspection. For guidance of users, a graph indicating the variation of depth of penetration with frequency of alternating current through the test coil for various materials is given in Appendix A.

4.2 Other Accessories — A recorder (X-Y-Z storage oscilloscope), an alarm or a marking system shall be used along with the main equipment.

4.3 Driving System — A material transport and guiding system shall be provided, if necessary, which will advance the tube at the required rate. There shall be no excessive vibration or misorientation of the tube and the feed speed shall be constant within $\pm$ 10 percent. The driving system shall in no way damage the tubes being tested.

4.4 Magnetic Saturation Unit (Applicable for Ferrous Pipes and Tubes) — To achieve the desired degree of magnetic saturation, a suitably cooled coil energized by direct current and surrounding the test coil assembly and the material under inspection may be used. Permanent magnets may also be used to achieve the required saturation. The absence of permeability noise may be taken as an indication of sufficient saturation.

5. TEST PROCEDURE

5.1 Reference Standard

5.1.1 A reference standard free from natural defects and of convenient length shall be prepared from a length of tube of the same size, composition and metallurgical conditions as the tubes to be inspected. The reference standard selected shall exhibit low background noise when it is tested at high sensitivity.

5.1.2 Holes drilled through the wall radially or rectangular notches cut on the outside surface of the tube shall be used as reference defects. Three such defects shall be introduced in the reference standard suitably separated (about 450 mm) from one another and from the end axially, and 120° apart circumferentially. While drilling the hole or cutting the notch, care shall be taken to avoid overheating of the area and to remove excessive burrs on the surface. The use of centre-punch shall be avoided. The surface shall not be damaged while handling.

NOTE 1 — The reference standard shall be frequently examined for damages like scars and dents.

NOTE 2 — Unless, otherwise agreed, longitudinal notches shall be used. Notches on the inner surface shall be used if mutually agreed between the manufacturer and purchaser.

NOTE 3 — When a single notch or drill cut on the reference standard is used, rotate the calibration standard in 120° increments and adjust the equipment so as to get equal responses from the artificial discontinuity.

5.1.3 The diameter of the holes or the dimensions of the notches may be according to the product specification and shall be subject of agreement between the contracting parties. Appendix B may be used as a guideline for the dimensions of the reference holes or notches.

5.2 End Effect — The end effect should be determined by drilling a series of holes or notches near one or both of the ends of a special calibration tube and passing the tube through the tester to determine the distance from the tube end at which the discontinuity is not detected.

When notches or holes are made at one end only, pass the tube through the coil twice, once each with the notches or holes at the leading and tailing ends.

The end effect shall be determined only once for each size, gauge, speed and test frequency. It need not be repeated during each calibration check.

5.3 Surface Preparation — The surface of the tube shall be free from metallic particles, other foreign materials and roughness that may interfere with the interpretation of the test results.

5.4 Adjustment of the Instrument — The reference standard shall be passed through or in the proximity of the test coil at the same speed and in the same manner as the tubes would be passed during inspection. The instrument settings, the frequency and the speed of the test shall be optimized to get consistently more or less equal and distinct indications from all the three reference defects. The alarm level shall be so set that an alarm is given each time a defect passes the test coil. This setting of the instrument should not be altered during testing of the subsequent lot.

5.5 Method of Testihg — The tubes shall be passed through or in the proximity of the test coil with the speed being maintained within $\pm$ 10 percent of its nominal value. Webbling, vibrations, and the misorientation of tube axis with respect to coil axis shall be kept minimum. Any section or length of tubing giving a defect indication equal to or greater than that produced by the reference standard shall be segregated from the material producing indication of lesser electrical magnitude.

5.6 The proper functioning of the equipment shall be checked (a) at the beginning of the test, (b) every four hours during production run (c) after finishing the test, and (d) whenever malfunctioning is suspected. If malfunctioning is confirmed all the tubes which have been tested since the last satisfactory calibration shall be re-tested.

5.7 In the case of inspection of ferrous pipes and tubes, provisions shall have to be made for demagnetizing the tubes, if necessary, after inspection.

6. LEVEL OF ACCEPTANCE

6.1 The acceptance standard shall be subject to agreement between the contracting parties. All indications of discontinuities which are equal to or greater than the agreed values may be the cause for rejection.

6.1.1 In case higher sensitivity is required, the test jobs should be subjected to magnetic stray flux testing, magnetic particle testing or ultrasonic testing as complementary method for assessing the presence or absence of discontinuities.

7. REPORT OF TEST RESULTS

7.1 The test report shall contain the following information:

a) Component drawing reference number where applicable;

b) Specification of material, including its dimension;

c) Surface condition of the tubes;

d) Make of the instrument;

e) Description of the coil assembly including inner diameter of test coil, method of magnetic saturation;

f) Frequency used and instrument setting;

g) Location size and extent of defects;

h) Recorder chart where available; and

j) Any unusual occurrence encountered during the test.

APPENDIX A

(*Clause* 4.1)

VARIATION OF DEPTH OF PENETRATION WITH FREQUENCY OF ALTERNATING CURRENT

Figure 1 indicates the variation of depth of penetration with frequency of alternating current through the test coil for various materials.

APPENDIX B

(*Clause* 5.1.3)

RECOMMENDED DIMENSIONS OF REFERENCE HOLES AND NOTCHES

B-1. The following table may be used as a guide for determining the size of the holes when they are used as reference standard:

Outer Diameter of Tube (*Nominal*) mm		*Diameter of the Drill* (*see* IS : 5101-1969*) mm
Above	Up to and Including	
—	6	0·50
6	19	0·65
19	25	0·80
25	32	0·95
32	38	1·05
38	44	1·15
44	50	1·30
50	63	1·65
63	140	2·7
140	250	3·2

NOTE — The diameter of the hole may have a tolerance of $+\ 0{\cdot}18\ {}^{0}_{-0}$ mm.

*Specification for twist drills, parallel shanks, jobber series.

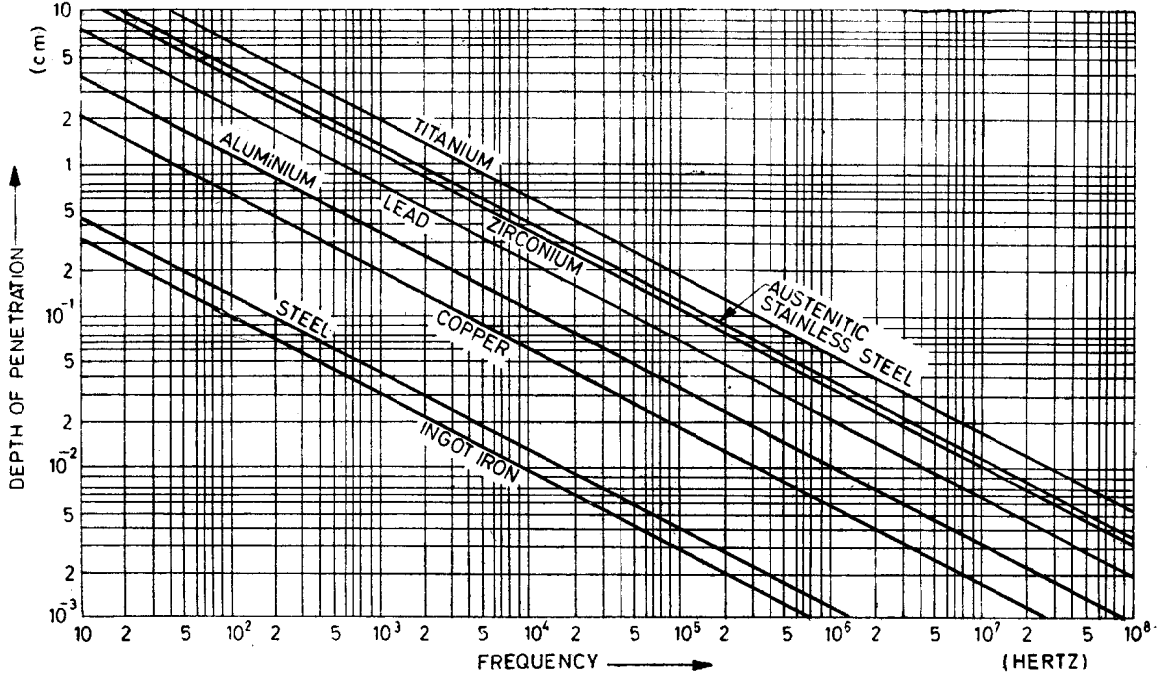

FIG. 1 DEPTH OF PENETRATION/FREQUENCY CHART

B-2. When the standard defect is a notch, the notch shall have the following dimensions:

Notch length	6-25 mm
Notch width	1 mm, *Max*
Notch depth	This is usually specified as a percentage of nominal wall thickness *t*, that is 5-percent and 10-percent depth notches

a) *5-Percent Depth Notch*
5 percent *t*, ± 15 percent with minimum of 0·3 ± 0·05 mm.

b) *10-Percent Depth Notch*
10 percent *t*, ± 15 percent with minimum of 0·3 ± 0·05 mm.

NOTE — Other notch depths and shapes may be used by agreement.